Diffraction methods of investigation of the periodical domain structures with inclined domain walls in lithium niobate

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Periodic domain structures (PDS) in ferroelectric crystals make possible to implement with high efficiency a quasi-phase-matched frequency conversion as well as an electro-optical deflection and switching of laser radiation [1-5]. For the domain sizes in such structures it requires reproducibility with accuracy below 20 nm [6]. It is known that real PDS in a $MgO:LiNbO_3$ crystal may have a tilt of the domain walls relative to the polar axis reaching as high as 0.2° and more [7, 8]. An effective method for determining the quality of a PDS is the diffraction of light, usually considered for structures with non-inclined domain walls [9-12].

In this report we present the results of an experimental investigation of Bragg diffraction on the PDS with inclined walls, which was produced in a $LiNbO_3$:5% MgO crystal by electric field poling. The model of perturbations of the optical properties of a crystal by domain walls, which has been used for consideration of such diffraction, should take into account their inclination from the polar axis *z* to small angle α (Fig. 1).

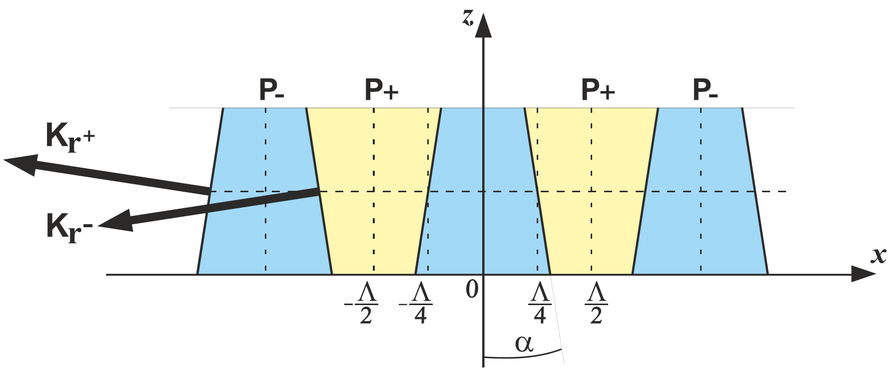

Figure 1. Schematic of the PDS with a spatial period Λ in lithium niobate crystal. Blue and yellow areas indicate the domains with opposite directions of the spontaneous polarization. The grating vectors $\mathbf{K}_{r+}$ and $\mathbf{K}_{r-}$ are shown separately for the two domain wall systems, inclined to the right and left. The angle α determines the inclination of the domain walls to the polar axis *z*.

We studied experimentally the Bragg diffraction on the PDS with the period Λ = 8.79 μm and the angle of inclination estimated as α = 0.31°. The sample has a thickness of *h* = 1 mm along the *z* axis. The interaction length of the light beam propagating in the *xy* plane at the Bragg angle to the *y* axis is 2 mm. All measurements are performed with a He-Ne laser beam (λ = 632.8 nm, *P* = 1 mW), having a Gaussian intensity distribution and a polarization vector oriented along the *z* axis. Focusing this beam by the lens with F = 350 mm allows to match its waist of 0.29 mm in diameter to the entrance face of the sample placed on the turntable. The position of the waist at the *z* axis near the middle of sample was chosen so that a symmetric distribution of the intensity in the first diffraction maximum was observed. Figures 2 and 3 show the images of diffraction maxima.

Thus, the analysis of the intensity distribution of the maxima with different orders observed at the Bragg diffraction on the PDS under study (Figs. 2 and 3) allows estimating the tilt angle of inclined domain walls of one.

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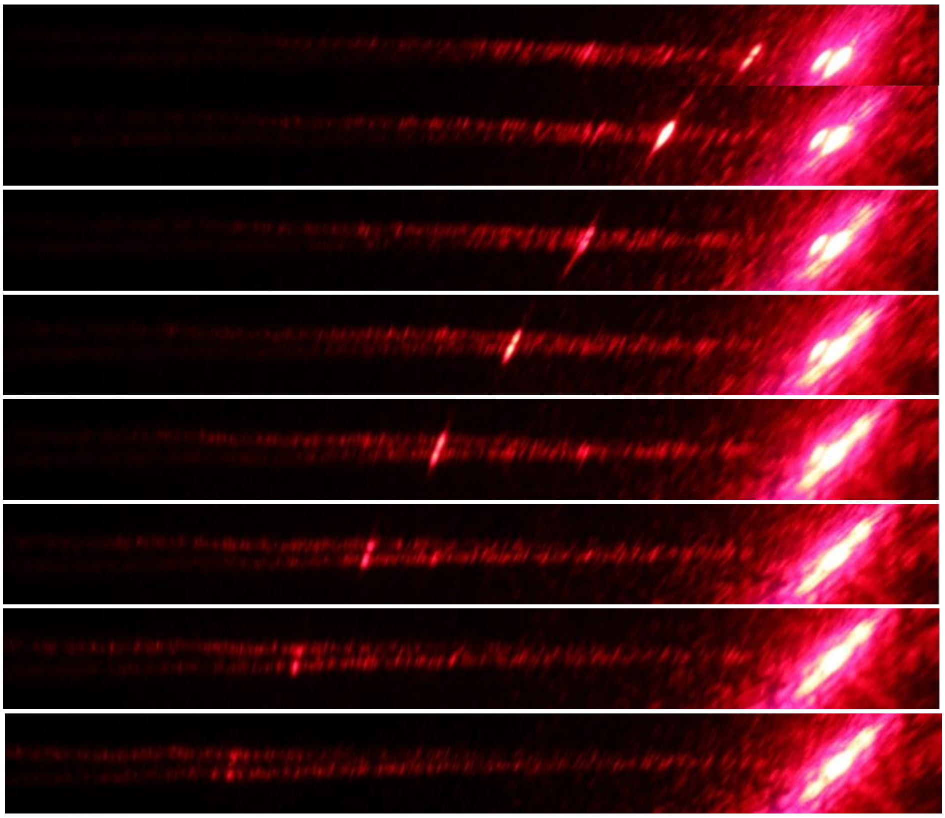

Figure 2. Images of Bragg diffraction maxima for orders from first to eight (from top to down) diverging in the directions specified by the vectors $\mathbf{K}_{r+}$ and $\mathbf{K}_{r-}$. These images were observed at the distance of 150 mm from the output face of the crystal.

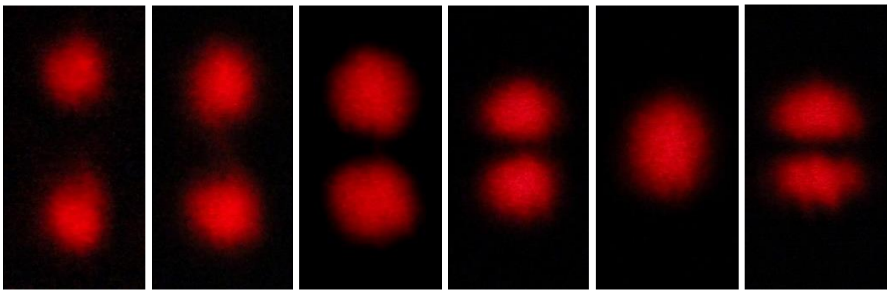

Figure 3. Images of Bragg diffraction maxima with orders from sixth to first (from left to right) observed in the far zone at the distance of 1650 mm from the output face of the crystal. The peaks in the maxima with the orders from 3 to 6 diverge in the directions specified by the vectors $\mathbf{K}_{r+}$ and $\mathbf{K}_{r-}$

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